Rotary Percussive Sample Acquisition Tool (SAT): Hardware Development and Testing

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Introduction

Hardware Development

Lessons Learned – Hardware Dev

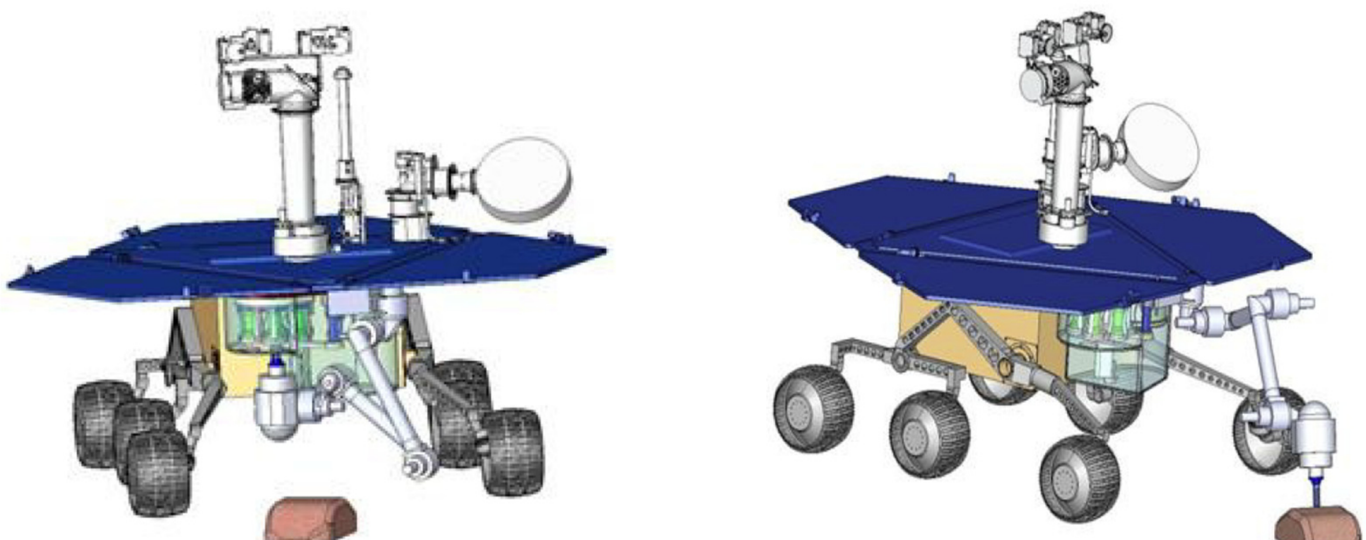
Test Results

Lessons Learned – Unit Testing

Conclusion

The work was performed as part of a potential Mars Sample Return (MSR) campaign

It is foreseen that a **Sample Acquisition and Caching (SAC)** subsystem would be necessary for acquiring and storing samples



Artist's Concept Rover based SAC Subsystem

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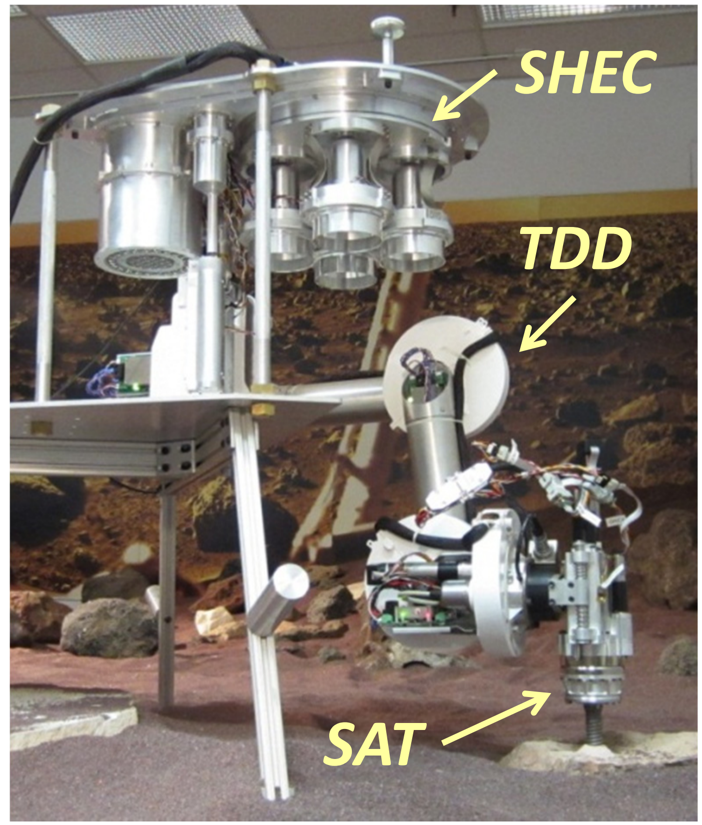
Integrated Mars Sample Acquisition and Handling (IMSAH) architecture has been proposed to satisfy potential SAC subsystem needs

Three main sub-elements:

1) Tool Deployment Device (TDD)
2) Sample Handling Encapsulation and Containerization (SHEC)
3) Sample Acquisition Tool (SAT)



IMSAH Hardware

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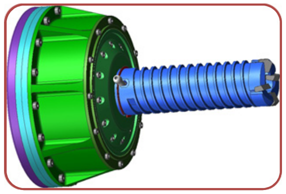
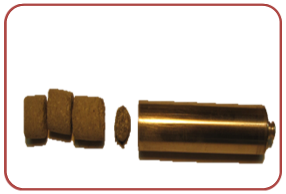
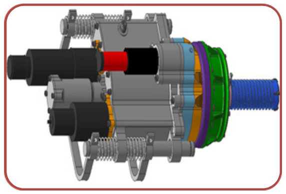
Key enabling **IMSAH** elements that allow for autonomous coring and caching:



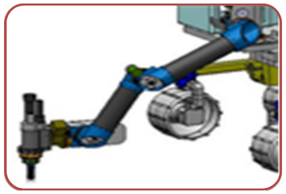
bit change-out for sample transfer



Core directly into individual sample tubes



Rotary Percussive Coring Tool (SAT) allows for reduced tool preload



5-DOF Robotic Arm (TDD) with force feedback

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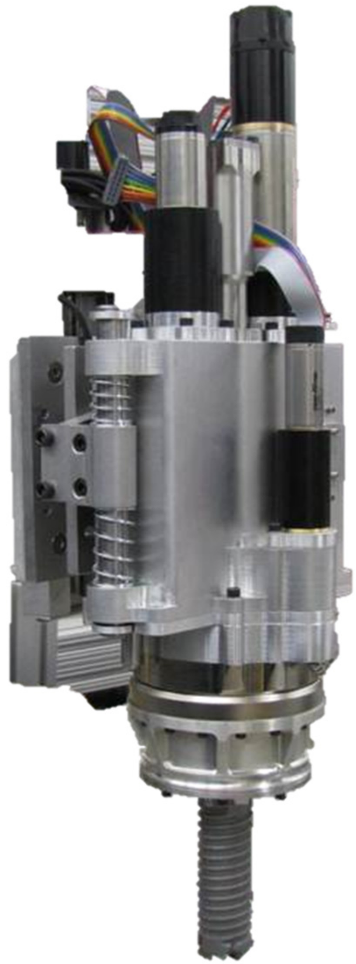
The **Sample Acquisition Tool (SAT)** is designed for autonomous:

- coring
- core fracture/retention
- bit change-out



SAT is a less complex coring tool design than what has previously been proposed:

- TDD can be used for tool feed
- Reduced tool preload

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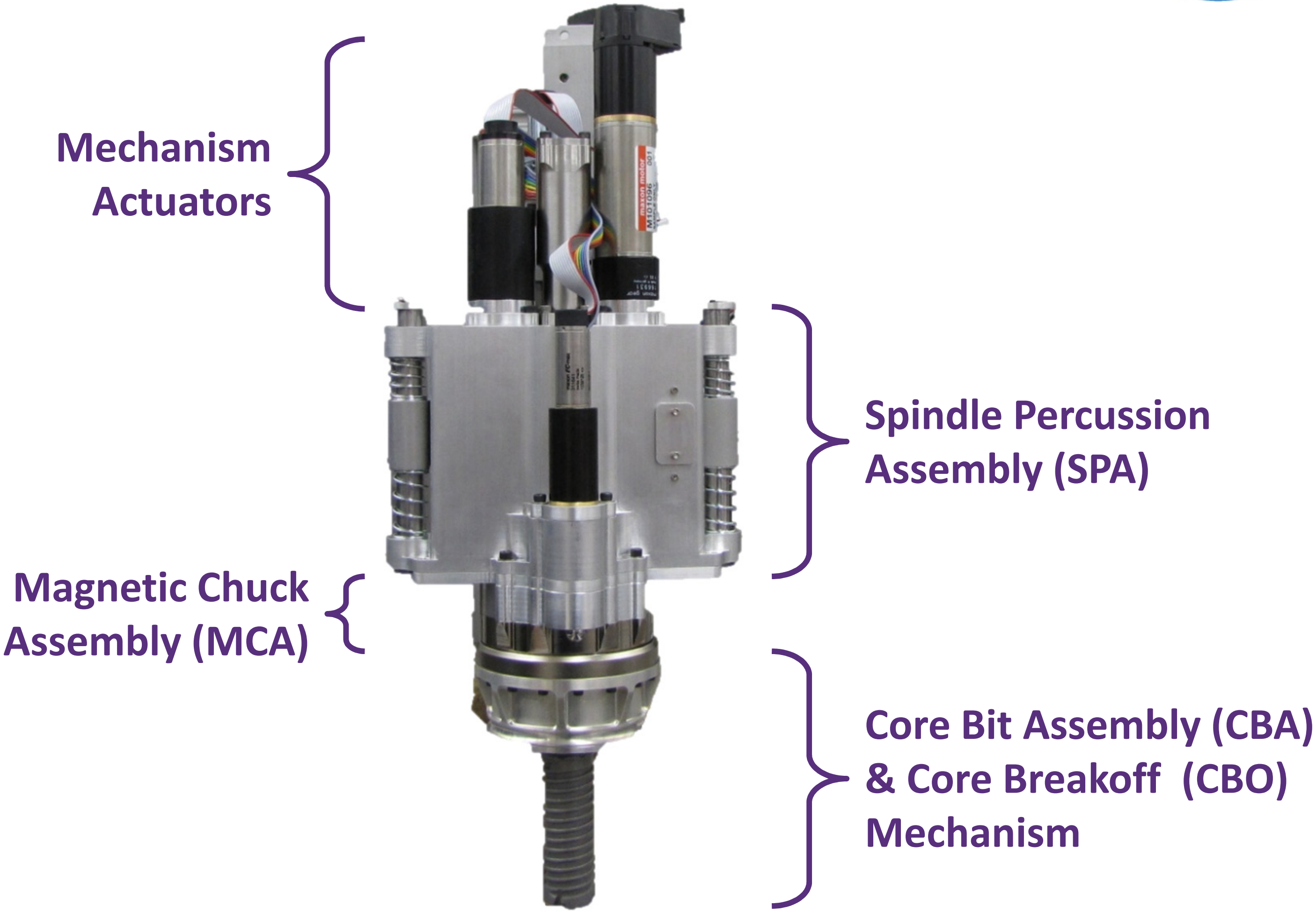
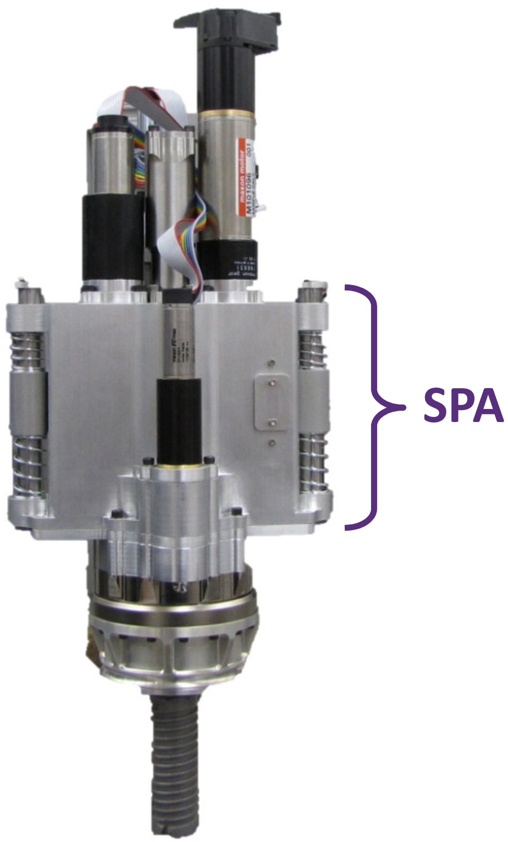
The **SAT** design is comprised of four main subassemblies

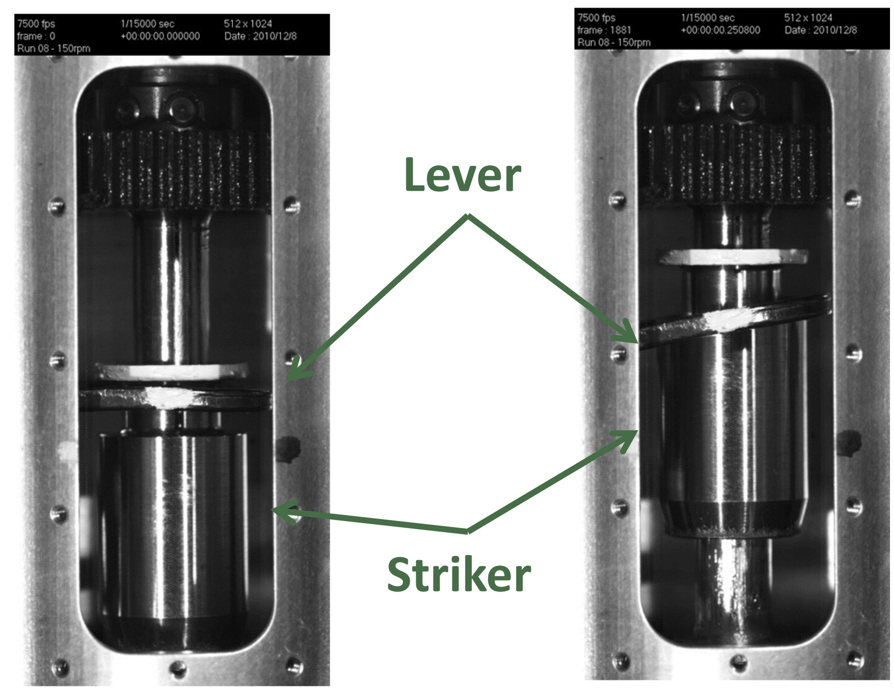


The **Spindle Percussion Assembly (SPA)** provides:

- rotational DOF to drive the CBA
- axial motion to drive the percussion striker mass

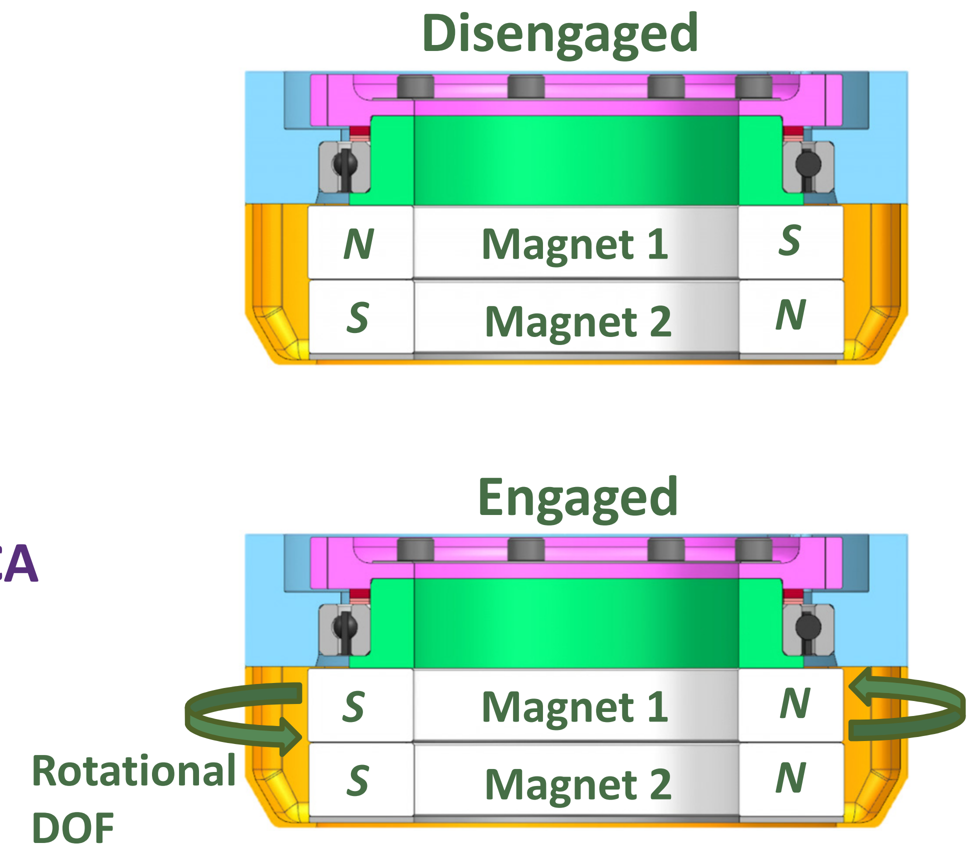


Percussion striker shown thru full range of motion



The **Magnetic Chuck Assembly (MCA)** utilizes two diametrically polarized permanent magnets

- Passive release of CBA under predefined side and/or axial loads



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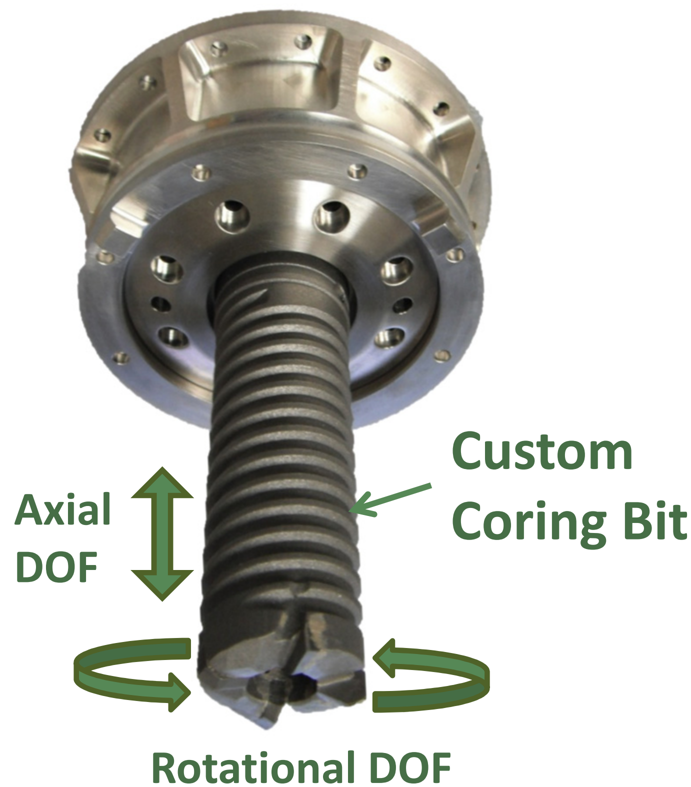
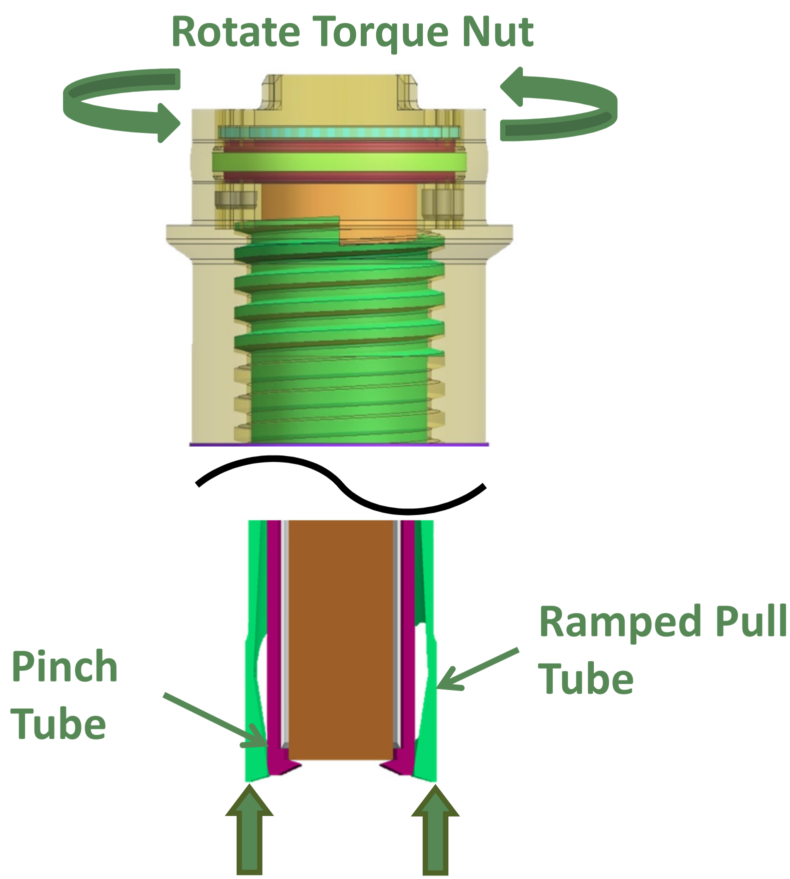
The **Core Bit Assembly (CBA)** uses a custom coring bit that functionally:

- allows engagement with the magnetic chuck
- accepts the rotational DOF from the SPA
- allows for an axial DOF for maximum transmission of impact energy



The **Core Breakoff (CBO)** mechanism uses a cleaving approach for core fracture

- allows for a well-controlled and predictable fracture plane



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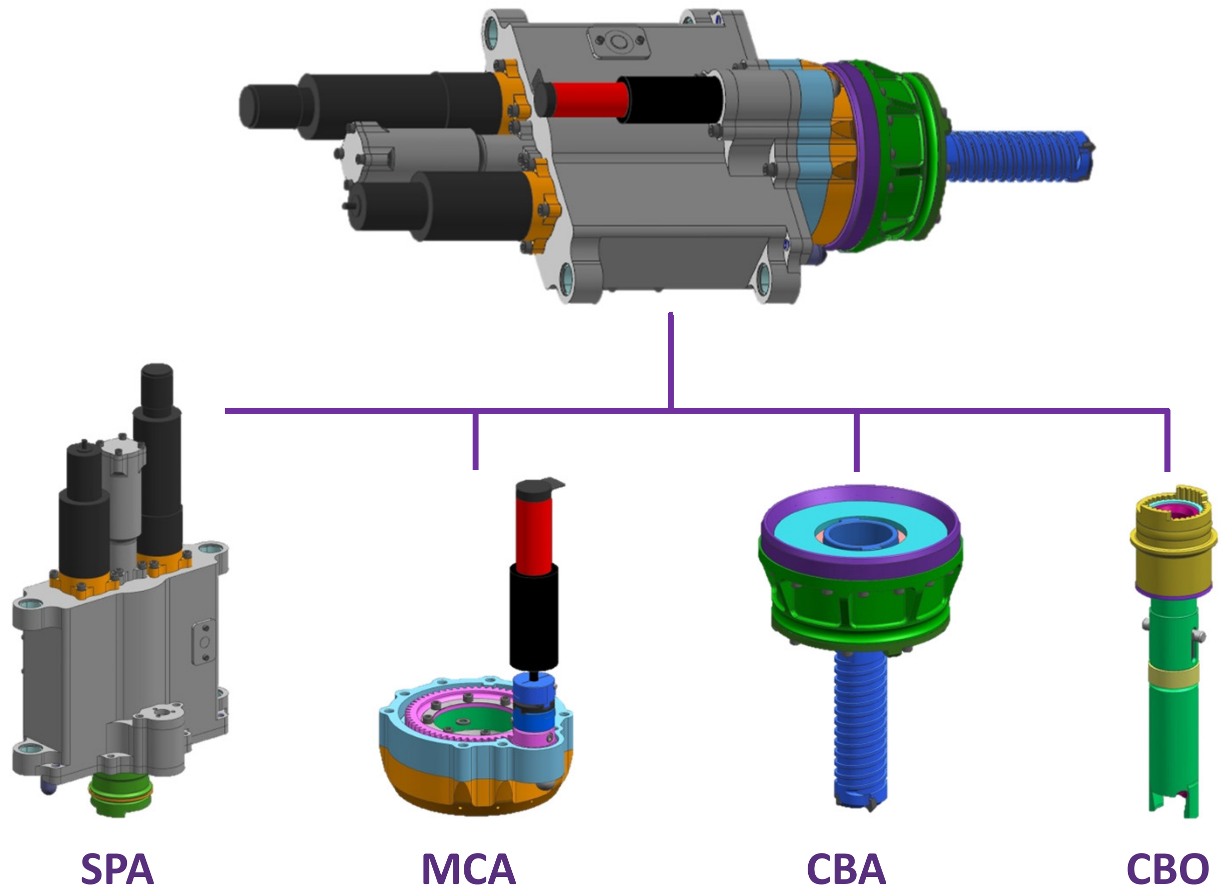
Overall **tool design philosophy** driven by schedule and resource limitations

Using ***lesson learned from MSL Drill development***, tool design was implemented using a modular approach

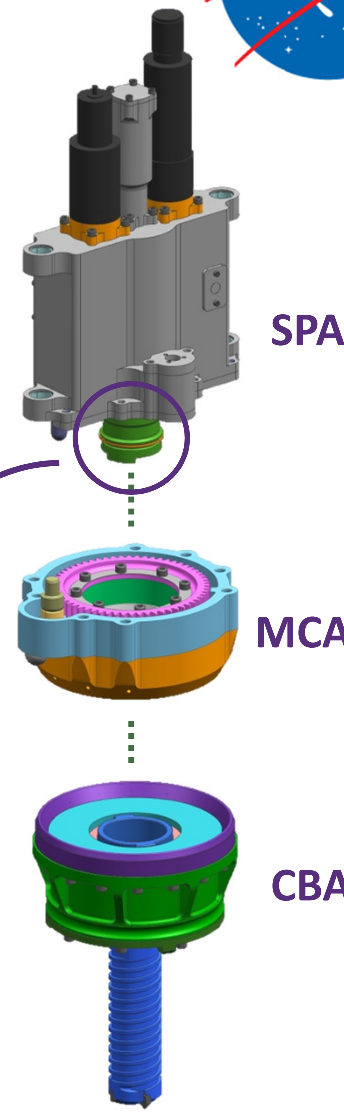


Novel chuck approach required **compromises** in material selection for torque couplings

Lesson Learned – anticipate impact of compromises early in design to allow for possible mitigation paths

New

Worn



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Modular design approach can accommodate interface growth relatively easily between sub-assemblies

Lesson Learned – remember the big picture! Interface growth at the sub-assembly level may result in failure to satisfy system level constraints and requirements

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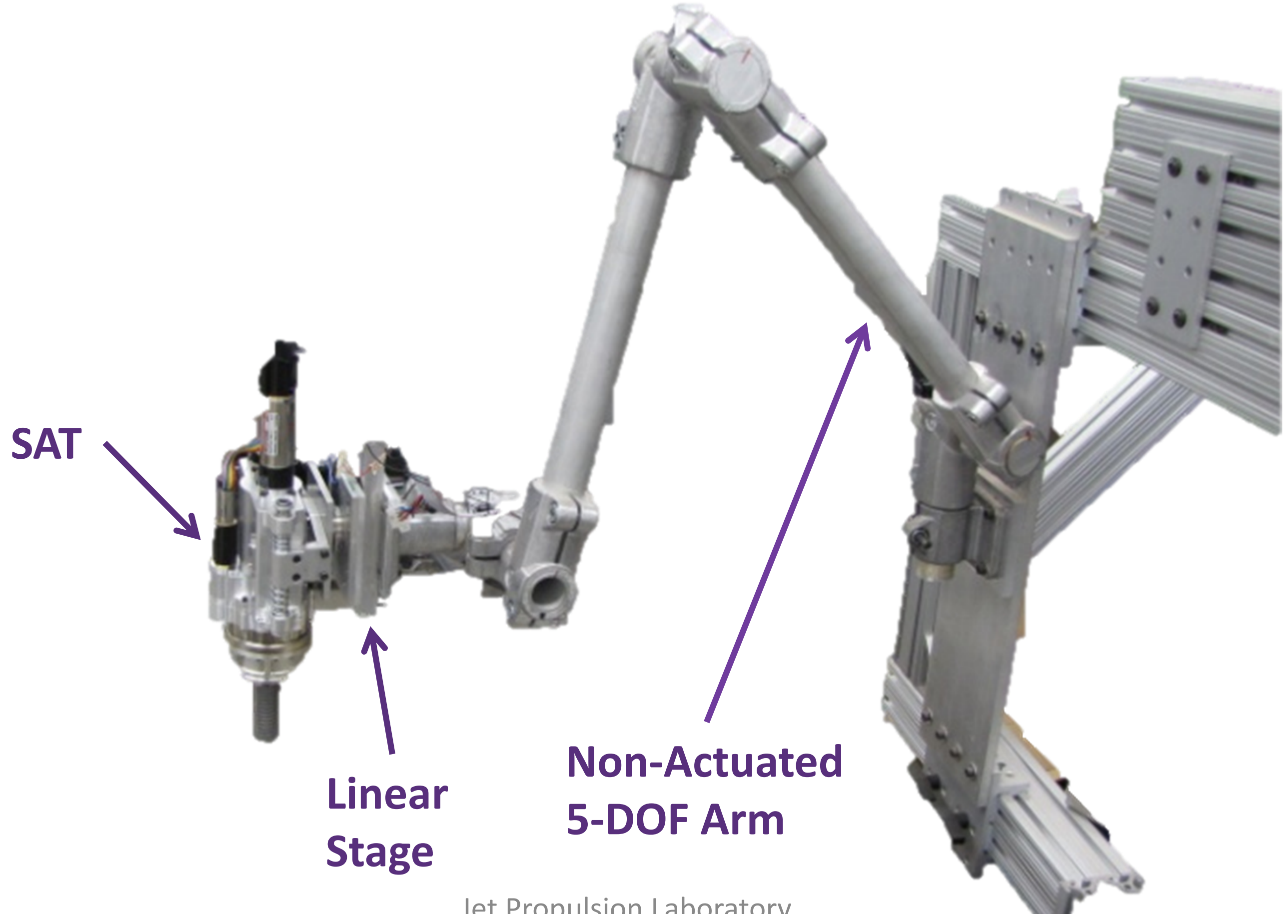
SAT assembly level test configuration

- Surrogate arm allowed for realistic boundary conditions
- No arm force feedback
- Used a linear stage for linear feed
- Used a force sensor for controlling weight on bit



Tool verification performed using **analogous Martian rock test suite**

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End-to-end unit level testing: core generation, fracture, and capture

Kaolinite
- Intact cores

Limestone
- Mostly intact cores

Siltstone
- Segmented disks

SB Basalt
- Mostly intact cores

V. Breccia
- Mostly intact cores

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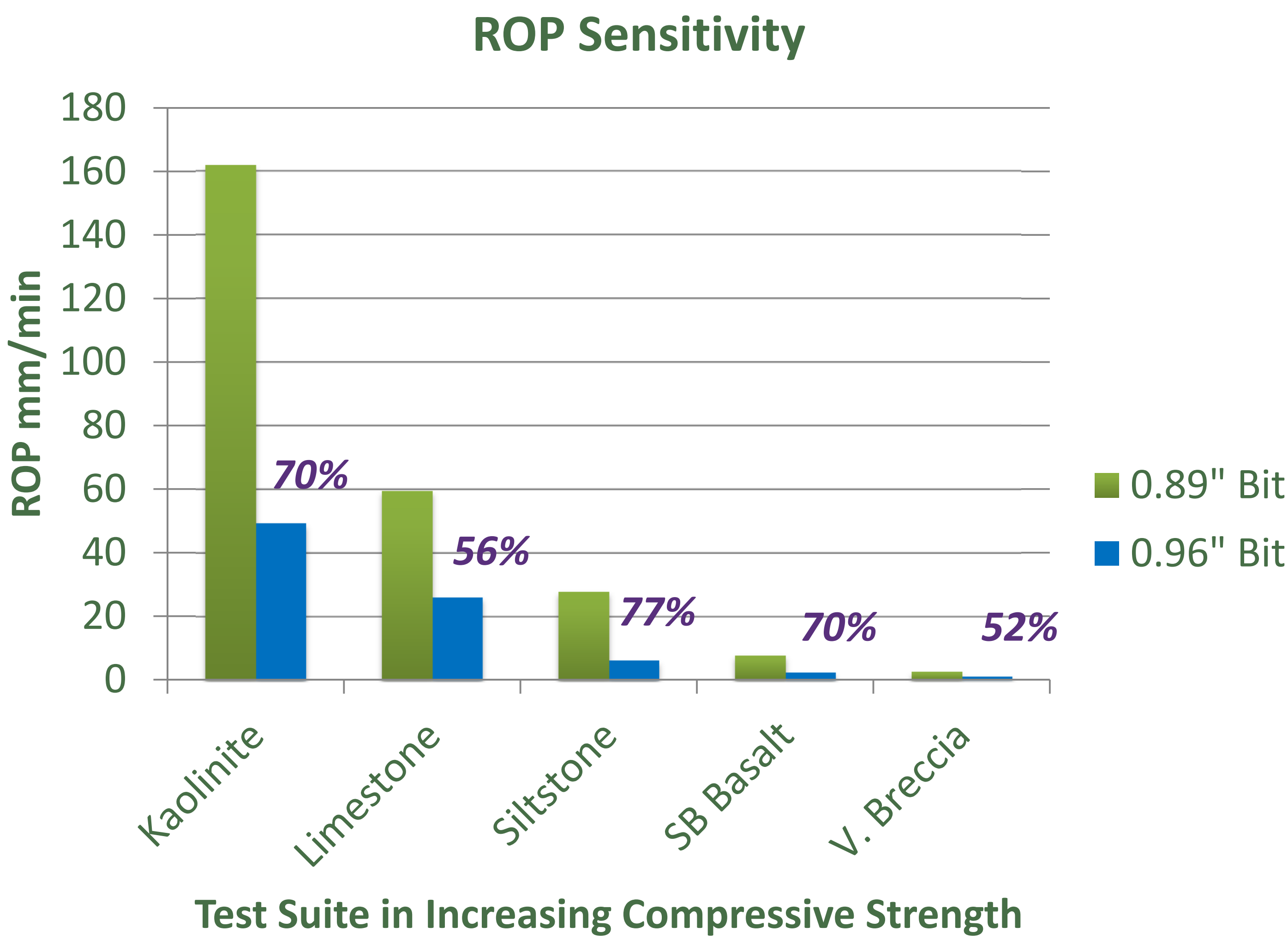
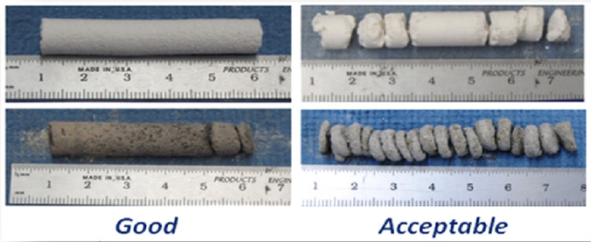
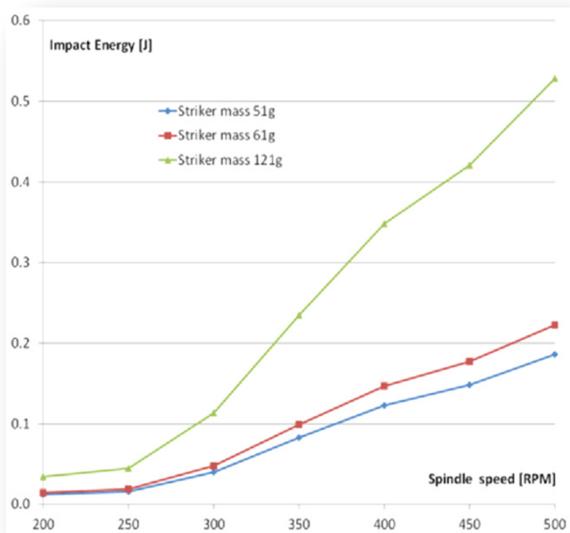
Lesson Learned – For development efforts with low maturity levels, emphasis should be placed on understanding performance sensitivities



Lessons Learned from unit level testing



Linked mechanisms result in reduced operational flexibility to investigate operational parameters vs. tool performance



For early proof of concept development efforts, focus energies on providing for large capability margins rather than design optimization approaches

Successfully demonstrated a low mass coring tool for autonomous core generation, fracture, and capture

Modular design approach selected due to schedule and resource constraints

For early development efforts:

- Pursuing de-coupled mechanism provides greater flexibility in terms of identifying operational parameter needs vs. performance

- Greater emphasis should be placed on understanding design sensitivities rather than design optimization

Questions?